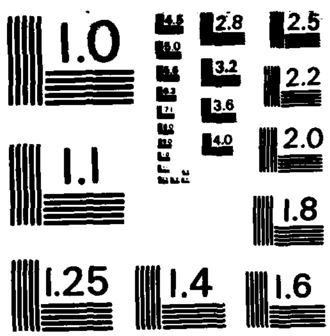
AD-A139 807 SYSTEM SAFETY AND THE COAST GUARD LIGHTER-THAN-AIR SYSTEM PROJECT(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA P J DANAHER DDC 83 1/1

UNCLASSIFIED F/G 13/12 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

2

NAVAL POSTGRADUATE SCHOOL
Monterey, California

AD A139807

THESIS

System Safety and the Coast Guard
Lighter-Than-Air System Project

By

Patrick J. Danaher

December 1983

Thesis Advisor: D.M. Layton

Approved for public release, distribution unlimited.

DTIC FILE COPY

DTIC ELECTE APR 05 1984 S E D

84 04 03 064

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A139 807	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) System Safety and the Coast Guard Lighter-Than-Air System Project		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis December 1983
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Patrick J. Danaher		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943		12. REPORT DATE December 1983
		13. NUMBER OF PAGES 84
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

United States Coast Guard, Aviation, Lighter-Than-Air,

Aviation Safety, Blimps

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Coast Guard is evaluating the potential of Lighter-Than-Air (LTA) vehicles for possible future Coast Guard utilization. Progress of the project is explored. Safety science is an emerging field particularly of value in the historically hazardous realm of aviation. The System Safety Concept as applicable to major project development is examined. One of the fundamental tasks of system safety management is to identify possible hazards early in the conceptual phase of product

Block 20 Cont'd.

development. If the concept is not without historical precedence, part of this task is accomplished by examining historical safety records to identify potential hazards. To this end, records of Navy LTA mishaps are examined and comparisons are made to Coast Guard aircraft mishap records.

Accession For		
NTIS GRA&I		X
DTIC TAB		☐
Unannounced		☐
Justification		
By		
Distribution/		
Availability Codes		
Dist	Avail and/or Special	
A-1		

DTIC COPY INSPECTED 3

Approved for public release, distribution unlimited.

System Safety and the Coast Guard
Lighter-Than-Air System Project

by

Patrick Joseph Danaher
Lieutenant, United States Coast Guard
B.A., George Washington University, 1975

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
December 1983

Author: Patrick J. Danaher

Approved by: Donald M. Layton
Thesis Advisor

Roger Evered
Second Reader

Richard S. Elster
Chairman, Department of Administrative Science

K. T. Marshall
Dean of Information and Policy Sciences

ABSTRACT

The Coast Guard is evaluating the potential of Lighter-Than-Air (LTA) vehicles for possible future Coast Guard utilization. Progress of the project is explored. Safety science is an emerging field particularly of value in the historically hazardous realm of aviation. The System Safety Concept as applicable to major project development is examined. One of the fundamental tasks of system safety management is to identify possible hazards early in the conceptual phase of product development. If the concept is not without historical precedence, part of this task is accomplished by examining historical safety records to identify potential hazards. To this end, records of Navy LTA mishaps are examined and comparisons are made to Coast Guard aircraft mishap records.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

For over 30 years, up until 1961, the U.S. Navy maintained a fleet of 'Lighter Than Air' (LTA) craft known also as dirigibles, blimps, or simply airships. These craft combined, in a unique fashion, many advantages of both maritime patrol airplanes and ocean going ships. Like the airplane, the LTA can cover large surface areas from the vantage of high altitude and at relatively high speed; additionally it can hover like a helicopter. Its ship-like qualities include the ability to track other ships as well as interdict and even board when necessary. The LTA also possesses the long endurance capability of a ship. Despite these attractive features, the Navy gradually shifted focus away from LTA operations ceasing their use altogether by 1962 with the retirement of the last airships in the fleet. The postwar emergence of high performance aircraft, the rising cost of helium and what was then considered high costs due to the personnel requirements for handling airships were all contributing factors in ushering out the era of Naval airships.

As this era was drawing to a close the curtain was rising on a new field of scientific study; safety science in the 1950's was just emerging. The same technical advances in aviation, which hastened the demise of the airship, provided unprecedented challenges to those who would build and operate the increasingly complex high performance aircraft being produced. The new sophisticated systems were not only more expensive but much more demanding of the human elements involved. This situation posed increased risks[1], the minimization of which became the objective of a new profession--the safety analyst. The establishment of the Naval Aviation Safety Center (NASC) in 1955 followed by the establishment of safety programs in the various military services, marked the arrival of safety science as a separate and vital field of endeavor. A central concept in the new field is that of 'system safety':

> The system safety concept is the application of special technical and managerial skills to the systematic, forward-looking identification and control of hazards[2] throughout the life cycle of a project, program, or activity. The concept calls for safety analyses and hazard control actions, beginning with the conceptual phase of a system and continuing through the design,

---

[1]Risk, associated with likelihood or possibility of harm, the expected value of loss. [Ref. 1: p. 8]

[2]Hazards: The Safety person sees a hazard as an implied threat of danger, of possible harm. It is a potential condition waiting to become a loss. A stimulus is required to cause the hazard to transfer from the potential state to the loss. This stimulus could be component failure, a condition of the system (pressure, temperature, switching condition that is out of tolerance, a maintenance failure, an operator, or a combination of other events and conditions. More technically--a potential condition, or set of conditions, either internal and/or external to a system, product, facility, or operation, which, when activated by a stimulus, transforms the hazard into a real condition, or series of events which culminate in a loss (an accident). [Ref. 1: p. 6]

> production, testing, use, and disposal phases, until the activity is retired...involves a planned, disciplined, systematically organized, and before-the-fact process characterized as the 'identify-analyze-control method of safety. The emphasis is placed upon an acceptable safety level designed into the system prior to actual production or operation of the system. The system safety discipline requires timely identification and evaluation of system hazards--before losses occur. These hazards must be eliminated or controlled to an acceptable level to provide a system that can be developed, tested, operated, and maintained safely. Proper application of the system safety concept requires a disciplined use of technical methods, including management controls necessary to assure its timely and economical completion [Ref. 1: p. 9].

Today the impact of the safety field is very wide reaching. Perhaps the most evident contributions have been made in U.S. Air Force and NASA applications:

> The basic missile systems developed in the late 1950s and early 1960s demanded a new approach to examining the hazards associated with the weapons systems. The Minuteman Intercontinental Ballistic Missile (ICBM) was one of the first systems to have a formal, disciplined, system safety program associated with it. Much of the success of the NASA programs can be attributed to the effort that system safety played in the hazard identification, evaluation and control [Ref. 1: p. 11].

Systems developed prior to the advent of the system safety concept which have endured through today, or systems brought out of retirement pose problems for the safety analyst: in the past, safety programs were usually established piecemeal, based on after-the-fact philosophy of accident prevention. For example, an aviation approach is often called the "fly-fix-fly" approach: build it and fly it; if it doesn't work, fix it and try flying again. Safety is usually considered informally by those connected with an activity. When an accident occurs, an investigation is conducted to determine the cause. Accident causes are then reviewed and discussed to determine what must be done to prevent similar accidents. The resulting system modifications, retrofits, or correction of design safeguards or procedures are made to existing systems. However, corrections can be wasteful and costly and are usually vigorously resisted because of previously committed investments [Ref. 1: p. 9].

An event in the 1970s stimulated renewed interest in just such an abandoned system. The enactment of legislation in 1977 establishing a 200 mile zone of U.S. jurisdiction off the shores of the United States vastly expanded the responsibilities of the U.S. Coast Guard. The Coast Guard, tasked with enforcing Federal laws within the vast new areas, faced several challenges in exercising their policing authority. As a policing authority the tasks facing the Coast Guard can be summarized as follows:

1. The protection of resources, notably fishing stocks. This requires vessels to be identified, their fishing tackle to be examined and their catch quotas to be verified. 'Friendly' craft need to be positively identified and intruders warned off, or apprehended.

2. The detection and reporting of any illegal transit of the ocean space (e.g., illegal immigration, smuggling).

3. The monitoring of surface vessel traffic, particularly hazardous cargoes, enduring safe passage of oil and gas tankers both on the high seas as well as in congested coastal areas.

4. The monitoring of all forms of environmental pollution and the early discovery of oil spills, sea-bed well faults and associated problems.

5. The reporting of wrecks or hazards to navigation, and the inspection of emplaced buoys. [Ref. 2]

At present these activities are performed by ships and aircraft of the Coast Guard. The many advantages of the LTA, mentioned earlier, made consideration of the LTA a viable option in the minds of planners tasked with developing a program for carrying out the Coast Guard's new responsibilities. the acquisition and operational costs promised to e significantly lower than for any other maritime patrol aircraft or surface vessel, with lower manpower requirements than most otherwise employed surface vessels. Interest sine the late 1970s led to a project to evaluate the LTA option. The project is currently in a test and evaluation phase with a demonstrator LTA and the project is targeted for completion by FY 1989.

The following chapters explore the specifics of the Coast Guard's LTA project, the elements of system safety, and an analysis of the relative potential of the LTA from a safety perspective.

II. BACKGROUND: THE MPA AND THE COAST GUARD

The Coast Guard is a military organization. In contrast to the other U.S. military organizations, which are administratively attached to the Department of Defense, the Coast Guard is administratively attached to the Department of Transportation. During times of declared war, the Coast Guard falls under control of the Department of the Navy. The reason for this difference is that the Coast Guard is the only military service with Federal Law enforcement responsibilities. These responsibilities, while somewhat related to national security, are basically non-military in nature, hence the peace-time separation in administrative control. These responsibilities are formulated in several main objectives and are reflected in the operating programs of the Coast Guard.

A. COAST GUARD PRIMARY RESPONSIBILITIES AND PROGRAMS

-- Objective A - to minimize loss of life, personal injury, and property damage on, over and under the high seas and waters subject to U.S. jurisdiction.

-- Objective B - to facilitate transportation with particular emphasis on waterborne activity in support of national economic, defense and social needs.

-- Objective C - to maintain an effective, ready armed force prepared for and immediately responsive to specific tasks in time of war or emergency.

-- Objective D - to assure the safety and security of vessels and of ports and waterways and their related shoreside facilities.

-- Objective E - to enforce federal laws and international agreements on and under waters subject to the jurisdiction of the U.S. and under the high seas where authorized.

-- Objective G - to cooperate with other governmental agencies and entities (federal, state and local) to assure efficient utilization of public resources, and to carry out activities in the international sphere where appropriate in furthering national policy. [Ref. 3: pp. 9-10]

These responsibilities have been embodied in the operating programs of the Coast Guard, for planning, budgeting and controlling purposes.

1. <u>Short-Range Aids to Navigation and Radionavigation Aids (ATON)</u>

   Facilitation of safe and expeditious passage of marine traffic is the purpose of a system of over 47,000 buoys, lights, radio beacons and daymarks, and numerous Loran and Omega stations which provide far-reaching continuous electronic navigation for ships and aircraft.

2. <u>Enforcement of Laws and Treaties (ELT)</u>

   Protection and preservation of natural resources and national interests in U. S. territorial and adjacent waters is one of the oldest functions but is particularly significant since the country established a 200-mile economic management zone for its coastal waters. The program encompasses surveillance of foreign fishing fleets, suppression of smuggling and other illegal activities and enforcement of environmental protection regulations.

3. <u>Military Preparedness and Military Operations (MP/MO)</u>

   By law the Coast Guard must maintain itself as a ready, effective armed force, prepared for specific tasks in time of war or national emergency. Coast Guard units operate with the Navy to train and support some naval operations. The service is transferred to the Navy Department at the direction of the President for wartime utilization.

4. Commercial Vessel Safety (CVS)

In order to prevent injury and death, property loss, and environmental damage, the Coast Guard administers regulations governing commercial vessels and oil rigs. Safety standards are implemented through vessel and equipment inspection, vessel documentation, licensing of seamen and investigation of accidents and violations.

5. Search and Rescue (SAR)

Perhaps the most glamorous of the operating programs, the assistance of persons and property in distress extends to U.S. jurisdictional waters, the Caribbean Sea, and most of the North Pacific and North Atlantic Oceans. An estimated 4300 lives and $268 million in property were saved in 1973.

6. Recreational Boating Safety (RBS)

This program seeks to minimize the loss of life and property associated with recreational boating. Safety patrols are conducted, liaison with state and local agencies is maintained, equipment is approved for manufacture, and educational programs for the boater are promoted. The Coast Guard Auxiliary, a volunteer organization sponsored by the Coast Guard, provides valuable assistance in this functional area.

7. Domestic and Polar Icebreaking (DI, PO)

8. Port Safety and Security (PSS)

To reduce the risk of marine accidents, the Coast Guard monitors activity in ports and harbors and enforces a variety of laws and safety regulations. This involves supervision of vessels loading, carrying and discharging hazardous cargoes, investigation of accidents and violations, and managing traffic flows. The establishment of vessel traffic systems is the newest development.

9. Marine Science Activities (MSA)

Oceanographic and meteorological activities are conducted to support national marine science objectives and other Coast Guard programs. This includes data collection, conducting the International Ice Patrol in the North Atlantic and supporting scientific research efforts.

10. <u>Marine Environmental Protection (MEP)</u>

In order to prevent and minimize damage to the marine environment, the Coast Guard enforces laws and regulations in this area, maintains surveillance of coastal waters, administers a system of enforcement and maintains a cleanup capability. Pollution by petroleum products is especially significant and a continuing concern of the program.

11. <u>Bridge Administration (BA)</u>

Bridges crossing waterways are frequently impediments to the passage of marine traffic. The Coast Guard inspects bridges, issues permits to insure that marine needs are met, promulgates regulations for drawbridges, and supervises modifications to bridges creating undue obstructions.

12. <u>Support Programs</u>

Support of the operating programs is provided by communications, public affairs, research and development, personnel, civil rights, legal, engineering, fiscal and supply, health care, and intelligence/security programs. [Ref. 3: pp. 13-15]

Clearly the Coast Guard is essentially concerned with maritime matters. Under its jurisdiction are all the navigable waters of the U.S. as well as coastal areas today extending 200 miles off our shores. The primary resources of the Coast Guard for accomplishing its manifold missions are ships, boats, aircraft and the people who manage, maintain and operate them.

Today the Coast Guard operates with an annual budget of over 2.521 Billion dollars. There are 39,436 uniformed personnel in the active Coast Guard and an additional 12,000 in the Reserve; the number of civilian employees is 5,382 and the Coast Guard maintains a force of 45,000 trained volunteers in the 'Coast Guard Auxiliary'. The service operates 2000 boats and ships of various descriptions, as well as some 159 aircraft both fixed wing and helicopter. [Ref: 4]

In a continuing effort to maximize the utility of its limited resources for accomplishing its missions, the Coast Guard maintains a research and development office. (See Figure 1) [Ref. 3: p. 16]

B. MARINE PATROL AIRSHIP PROJECT

In 1977 the Coast Guard was faced with a difficult situation. Vastly increased areas of responsibility coupled with an essentially static budget stimulated planners' interest in searching for economical alternatives for carrying out Coast Guard missions. About this time, FY 1976, the U.S. Navy was conducting studies in the area of LTA vehicles. The Advanced Naval Vehicles Concept Evaluation (ANVCE) study, conducted by the Goodyear Aerospace Corporation, focused on generating analytical tools in terms of aerodynamic characteristics, stern propulsion characteristics and a VTOL (vertical take off and landing) flight dynamics computer simulation. The conclusions of the study were favorable for the Navy's interests. Design of a low-risk conceptual airship based on

Secretary of
Transportation

Commandant
Vice Commandant----Special Advisors

------------------------------------Chief of Staff

Commander,
Pacific Area

District
Commanders (5)

Operating
Units

Commander,
Atlantic Area

District
Commanders (7)

Operating
Units

Headquarters
Units (19)

--Office of Boating, Public,
and Consumer Affairs
--Office of Comptroller
--Office of Operations

--Marine Science & Ice
Operations Division
--Office of Chief Counsel
--Office of Engineering
--Office of Personnel
--Office of Merchant Marine Safety
--Office of Reserve
--Office of Marine Environment
and Systems
--Office of Research & Development
--Office of Health Services
--Office of Navigation

Figure 1. U.S. Coast Guard Organization

a U.S. Navy 1950's design of a ZPG-2W (See Figure 2) [Ref. 5] was produced. Operational characteristics for VTOL, resupply at sea and towed array ASW (Anti-Submarine Warfare) were evaluated as good. [Ref. 6: pp. 1-2]

The following year, FY 1977, the Coast Guard financed a study by the Center for Naval Analysis (CNA). This study, CNA 1078 (May 1978), examined LTA vehicles in performing the USCG missions of Enforcement of Laws and Treaties (ELT), Marine Environmental Protection (MEP), and Search and Rescue (SAR) with emphasis placed on the reconnaissance tasks involved in these missions. The results of this analysis were compared to similar data on Coast Guard operational hydrofoils used for fisheries law enforcement. Essentially the study analyzed the cost/performance of various conceptual airships. The analysis included an examination of the sensitivity of cost factors to certain characteristics (utilization rates, investment, personnel, maintenance, and fuel costs). The conclusions of this study were that based on miles of trail tasks and square miles surveiled, LTA vehicles were more costly than alternative vehicles. However, the Coast Guard took exception to these findings and continued exploration of the LTA alternative. [Ref. 6: pp. 1-2] A 1980 study by the Naval Air Development Center entitled <u>Marine Patrol Airship Study (MPAS</u>, March 1980) was commissioned for the Coast Guard to determine conceptual vehicle designs for specific Coast Guard mission

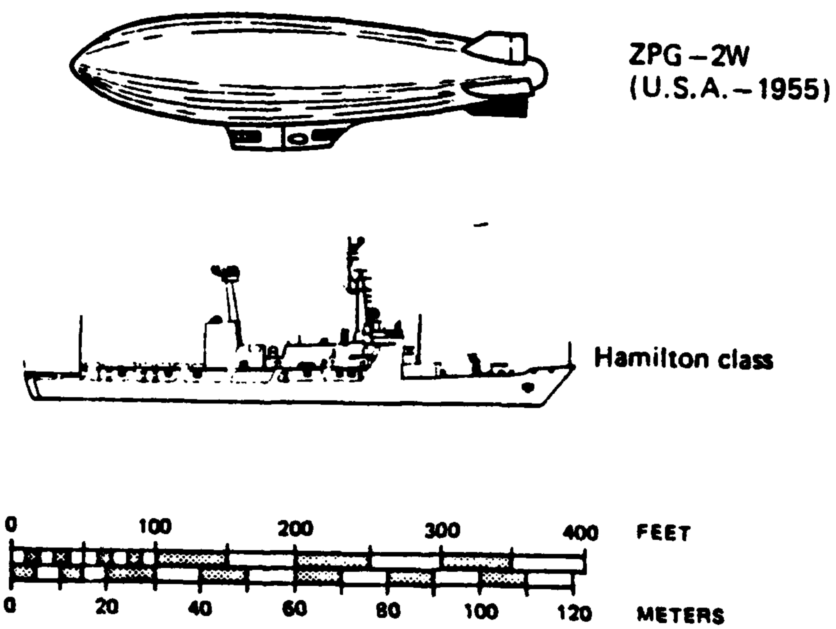


Figure 2. Comparison of a 1955 Blimp with a Hamilton Class Cutter

requirements including a cost assessment of a Coast Guard airship system. This study concluded that airships would be of direct benefit to the Coast Guard in mission accomplishment and that the airship could be cost competitive with other Coast Guard vehicles, e.g., aircraft and surface vessels. [Ref. 6: pp. 1-2]

The next step taken by the Coast Guard in pursuing its study of the LTA concept was as a minority partner in a multiagency technical evaluation of modern airships in 1979. The U.S. Forestry Service (USFS) Helistat Project sought to design and construct a 'heavy-lift' logging vehicle assembled from old (1950's vintage) GFE helicopters and a one million cubic foot airship envelope. The vehicle was being assembled to demonstrate logging operations in the Pacific Northwest. Due to the highly specialized nature of this specific design--heavy lift for logging operations--no promising conclusions regarding possible Coast Guard utilization of this particular airship were drawn.

At the present time the Coast Guard is conducting a four year, multimillion dollar program to flight validate the patrol airship concept in USCG operations. A competitive procurement is underway to design, but not build, a full-scale vehicle and to design, fabricate and test a reduced scale airship demonstration vehicle. The effort includes a comprehensive development of life-cycle costs and estimates of the survivability of this vehicle in Coast Guard operational weather conditions. To date a demonstration vehicle has been man-rated and has flown tests under Coast Guard mission scenarios. Table II-1 [Ref. 7] summarizes the activities included in the tests of the patrol airship demonstrator (PAD). The results of these tests are not yet available; the tests are in progress at this time but should be completed in FY 1984 [Ref. 6: p. 2] The project is titled: Lighter-Than-Air System Concept Definition.

The project narrative outlines the Coast Guard's continuing interest in the LTA concept:

> "Historically, the LTA type vehicle or airship has demonstrated one of the highest fuel efficiencies for aircraft. Because of this, the LTA concept has been identified as an approach warranting further examination.
>
> The application of modern technological approaches to the LTA concept has also created new interest in these vehicles as cost-effective, energy-efficient multimission platforms. Advances in materials, control systems, avionics, and propulsion developed for modern helicopter and aircraft systems can now be applied to the LTA concept to provide a reliable and efficient vehicle.
>
> In addition, many possible capabilities available from this concept are uniquely available in one vehicle and lend themselves ideally to the Coast Guard multimission approach. The ability to launch and recover a small boat for boarding operations, tow small craft or sonar arrays, and carry large payloads such as required in the MEP mission, are coupled with a 90 knot dash speed, 60 knot cruise speed, and long loiter and endurance capability. Due to this uniqueness, the LTA vehicle cannot be directly compared to either ship or aircraft platforms; however,an LTA vehicle would be highly useful in complementing existing and future ship and aircraft resources.
>
> The Coast Guard has indicated an interest in the LTA concept since the mid 1970's. Between 1975 and 1980, several conceptual studies of limited depth were performed and, in general, it appeared that an LTA system was at

Table II-1. LTA Test Plan, Mission Demo

1. Patrol/Transit/Search

Goal- discover & qualify the advantages of airship over F/W & R/W & Ships.

Expected advantages

1. discrete mission comparison
   - Fuel Consumption
   - Man hours committed
   - Probability of Detection (POD) achieved
   - CREW fatigue (Subjective)

2. Execution

a. Plan and execute a maximum endurance Radar/Visual or search pattern for small surface vessel @ 8 hrs.

Data:	Data Reduction:
Fuel log	Fuel consumption
WX, search conditions	POD
Flt crew focus of attention	POD-SQMI/hr.
lookout attention	Crew fraction for A/S ops
total mission flight time	Crew fraction for search
total crew mission time	Crew mission hrs/POD semi
Radar contacts	Compare to Vessel & C130
contact investigation/ identification	

b. Plan and execute a max endurance visual search pattern for raft, debris, PIW @ 8 hrs.

Data:	DR:
Same as above	Same as above + compare to Helo performance H-3 & H-65

c. Night search for small surface vessel, raft with IR/UV devices.

Data:	DR:
Same as above + Sensor contacts, effectiveness	Same as above

Table II-1 Cont'd

2. Station Keeping/Trail

Goal- to evaluate LTA vehicles ability to maintain trail on a vessel for extended periods of time.

Expected advantages: Low fuel consumption, less crew stress during trail, low crew workload during trail, overnight escort of distress vessel, low vulnerability to small arms fire.

Execution:

a. Establish trail on several moving vessels
   Data: Fuel Consumption rate
   Vessel description, CSE/speed
   WX & winds
   Crew stress for far offshore scenario
   Crew workload
   Trail options (range/altitude)

b. Establish trail on several drifting vessels
   Data: Fuel consumption rate
   Vessel description
   WX & winds
   Crew stress
   Crew workload
   best trail range/altitude options

3. HOVER/BOARD/Equipment delivery (beyond helo range)

Goals
- Equipment delivery to surface
- Personnel delivery to surface
- Personnel hoist from vessel
- Boat launch at sea
- Boat retrieval at sea

Expected advantages:
100% success delivery of equipment to vessel beyond helo range. Hoist person from raft/ship beyond helo range. Lower person to Ches. light cheaper than Helo (H-3, H-65)

Execution

Practice hover over land (heavy/neutral buoyancy)
Deliver equipment to spot on land
Deliver personnel to spot on land

Practice hover over drifting boat
Deliver equipment to drifting boat (with/without trail line)
Retrieve equipment from drifting boat
Launch Boat in river
Retrieve boat in river

4. <u>MSA demonstration</u>

Deploy CTD
Deploy AXBT
Deploy depth sounder

---

least cost competitive, and possibly more economical than other air and surface platforms which were considered.

Initial requirements (G-O Memorandum, serial 3900, dated June 4, 1980) identified by G-O indicate that the increase in the emphasis of the surveillance role in Coast Guard missions and rising fuel costs make an extended endurance air platform a desirable asset. The LTA vehicle is a highly stable, quiet, and fuel efficient surveillance platform. It is likely that in the long term, fuel cost will increase more rapidly than the overall inflation rate and it will become a larger fraction of direct operating costs (DOC) and life-cycle cost (LCC). Therefore fuel performance will become an increasingly important, primary measure of merit in vehicle design. In this respect the LTA concept is very attractive.

Initial requirements (G-W Memorandum, serial 1649/11, dated April 17, 1980) identified by G-W also indicate the need for an extended endurance air platform. In addition, Coast Guard MEP mission requirements indicate the desirability of an on-scene logistics supply and support capability to deploy and retrieve a small boat, to deliver payloads of up to 9 tons, and to tow operating oil recovery devices. A hover capable LTA platform is capable of accomplishing these tasks." [Ref. 7: p.2]

There are some notable obstacles and risks associated with this LTA project. One assumption made by planners is that an airship will be available for purchase or lease that will have the necessary capability to demonstrate a significant capacity for patrol mission performance and will make use of improved technology in structure, propulsion and control. In a patrol ship demonstrator, these assets would be necessary in order to project an accurate picture, for evaluation, of the final MPA system.

Planners note that only one American firm and two European firms are known to be operating airships at present. Considering the limited financial resources allocated to the project, unless private industry is willing to invest resources, competition will be very limited.

Environmental limitations, especially limits imposed by moderate to high gusting winds, which define the operating envelope for the airship, are the prime technical concern. Historical data indicates that U.S. Naval airships did operate year round from bases as far south as Key West, Florida to as far north as South Weymouth, Massachusetts, sometimes under subfreezing temperatures and in winds exceeding 50 knots. However, historical data also indicates that gusting winds above 10-15 knots did adversely affect some (especially landing and masting) operations. The records indicate that a higher degree of near ground (or water) controllability and responsivity is needed in gusting wind conditions.

System costs and cost benefit ratios for the airship must also be obtained. This will involve not only the costing of the airship but also will consider system size and distribution, size requirements, maintenance requirements, personnel and training and all other support requirements for an airship system. [Ref. 8]

Appendix A explores in detail the design mission scenarios to be studied during the patrol airship demonstration phase of the project. [Ref. 9]

It is still too early in the evaluation process to predict whether and to what extent the LTA concept may figure in the Coast Guard's future. Should the conclusions of this project be favorable for developing an LTA fleet for Coast Guard operations, many other hurdles lay ahead. would the LTA replace other aircraft in the inventory or merely be a supplement? Will funds be available for acquisition? a myriad of issues remain to be resolved. The acquisition of such a major system should include careful consideration of the safety issues attendant. The next chapter explores the concept of system safety, certainly an important concept with applications for the development of an LTA vehicle.

III. THE FIELD OF SYSTEM SAFETY

The system safety concept is the application of special technical and managerial skills to the systematic, forward-looking identification and control of hazards throughout the life cycle of a project, program or activity. [Ref. 1: p.9] The emphasis is placed upon an acceptable safety level designed into the system prior to actual production or operation of the system. It requires timely identification and evaluation of system hazards--before losses occur. These hazards must be eliminated or controlled to a tolerable level to provide a system that can be developed, tested, operated, and maintained safely. Proper application of the system safety concept requires a disciplined use of technical methods, including management controls necessary to assure its timely and economical completion. [Ref. 1: p. 9]

A. SYSTEM SAFETY DEVELOPMENT

As opposed to older traditional safety tasks, which are qualitative in nature, system safety is more quantitative in nature and is rooted in systems and operations research technology. Its early military applications included, for example, assuring that inadvertent nuclear explosions would not occur and that space travelers would be safe in their journeys. System safety is now used in a multiplicity of domains from aviation to mass transportation, petroleum production and distribution, nuclear power plant construction, and chemical facility design. [Ref. 1: p. 11]

The basic objective of a system safety program is the elimination or control of hazards, which will reduce the potential loss of a system, reduce the potential injury or morbidity, and reduce the potential damage to the system or related equipment to an acceptable level. [Ref. 1: p. 14]

The complexity and involved interrelationship of elements within, and external to, a system require detailed system safety studies. Potential hazards are detected and the probability of occurrence is estimated. The phases include normal operational modes, maintenance modes, failure modes of the system, failures of adjacent equipment, and errors created by human performance. On summary, the principle goal of a system safety program is the creation of a reasonably safe product. [Ref. 1: p. 14]

B. SYSTEM SAFETY TASKS

System safety task requirements include:

- Safety management
- Safety engineering
- Safety analyses
- Hazard identification
- Hazard description
- Cause determination
- Hazard control
- Control evaluation
- Documentation

The tasks are performed, ideally, throughout the life cycle of a product or system. The six common phases of a life cycle are Concept (Conceptual research), Definition (Design validation), Development (Full-scale development), Production (Manufacture), Deployment (Operation-maintenance), Disposition (Termination-retirement). There are four major control points for system safety in the development of a system; they are the end points of the phases of concept, definition, development and production. Figure 3, [Ref. 1: p. 24], illustrates the specific control processes. The value of the review process is critical to reducing the number of defects and oversights that commonly enter the operational phase. Costs incurred by not correcting defects until the operational phase can be two to ten times the costs resulting from changes in a proper review. [Ref. 1: p. 25]

There are primary safety program tasks to be accomplished during each phase of system development.

C. SYSTEM SAFETY PHASES

During the concept phase historical data and future technical forecasts are used to provide a basis for the proposed system. Critical issues related to the product are examined, system safety concerns with types of hazard are identified, and their impacts are evaluated. A preliminary hazard analysis (PHA) is an analytical tool used during the

Phase	Safety Control Point	Result
Concept	Concept design review	Establish basic design for general evolution
Definition	Preliminary design review	Establish general design for specific development
Development	Critical design review	Approve specific design for production
Production	Final acceptance review	Approve product for release in deployment
Deployment	Audit of operation and maintenance	Control of safety operation and maintenance

Figure 3. System Safety Phases

concept phase to bring out the hazards that would be involved with a specific concept. Risk analysis (RA) on a gross level would also be performed to determine the immediate needs for hazard control and development of safety design criteria. Also during the concept phase, system safety management requires the development of a system safety program plan (SSPP), identifying the tasks to be accomplished in the total safety program for the evolution of the subject system. The effort to develop a SSPP at this time is of major importance to assure that safety is examined in a logical, sequential manner throughout the entire program. [Ref. 28: pp. 25-26] Three basic questions should be answered at the close of the concept phase.

1. Have hazards associated with the design been discovered and evaluated to establish hazard controls?

2. Have risk analyses been initiated to establish the means of hazard control.?

3. Are initial safety design requirements established for the concept so that the next phase of system definition can be initiated? [Ref. 1: p. 27]

During the Definition phase the safety tasks are verification of the preliminary design and engineering of the product. The SSPP should identify the analyses that should be conducted. An examination of the hazards of several designs may be required. An updating of the PHA is accomplished, along with initiation of the subsystem hazard analysis (SSHA) and later integration into the system hazard analysis (SHA). Risk analysis is employed to evaluate the different hazards identified and considered in the preliminary stages. Examination of risk is the key to selection of final design. One or more safety analysis techniques may be needed to identify the following: safety equipment, specification of safety design requirements, initial development of safety test plans and requirements, and prototype testing to verify the type of design selected. Not all hazards will be known at this time, since the design is not yet complete. [Ref. 1: p. 28]

The development phase allows system definition to include environmental impact, integrated logistics support, producible engineering, and operational use studies. Prototype analysis and testing results are used as inputs for a comprehensive operating hazard analysis (OHA) to examine human-machine hazards. Interfaces with other engineering disciplines will have been exercised in this phase, particularly reliability engineering with the review of the failure modes and effects analysis (FMEA). Failure modes that are hazardous should have been clearly identified in the hazard analysis, and action should have been taken for their control. The completion of the development phase leads to a go/no-go decision on a specific design before production begins. The ability to make the correct go/no-go decision is based upon completion of hazard analysis, safety testing results, and complying with safety design criteria. [Ref. 1: p. 28]

Monitoring by the safety staff during the production phase is most important. Inspection and testing of the product for quality control is performed and requires the interaction of the safety and quality control departments. Attesting to the quality of safety devices requires the presence of system safety personnel. Training is initiated during this phase. Safety personnel must monitor the total training program to assure that safety training is occurring. Updating of the analyses performed during the definition and development phases will occur during this phase. An objective review of past hazard analyses to verify that corrective action for hazards has been incorporated in the manner set forth in the documentation is required. Any changes necessitated at this time will be subject to review and verification during the final acceptance review (FAR). Finally, the system safety engineering report (SSER) is a compilation of the production phase inputs that identifies and documents the hazards of the final product or system. This report should disclose the safe use of the product in the environment in which it may be deployed. Basically, it represents the data obtained from the analyses, testing, and design criteria evolution. The SSER should provide definite conclusions about the safety integrity of the product and the means by which specific hazards identified have been controlled. [Ref. 1: p. 29]

The deployment phase follows system acquisition, development, and production. At this time the system becomes operational. During this phase training of users is conducted and data are accumulated (from production failures, field failures, and accidents and incidents that have occurred). System safety management has to be available to follow up on any problem that may arise during this period, and a system safety person should participate in the work of the investigation board so that identification of hazardous conditions can be made as soon as possible and corrective actions can be devised in coordination with designers and reviewed by responsible safety personnel. If engineering or design changes after deployment occur, it is necessary that the system safety personnel have an opportunity to review changes that may be submitted so that no new problem is introduced into the system as a result of an engineering change. [Ref. 1: p. 30]

Finally, a sixth phase--termination--may be significant because of certain elements of the design or the presence of hazardous materials. The system safety person should be available to check out the previously developed procedures for the product termination and to verify that the method employed is carefully monitored. Since the actual termination occurs at the end of operation, monitoring can often be performed on a sampling basis to verify the correct use of the termination procedure where it involves a hazardous situation or substance. [Ref. 1: p. 30]

D. SYSTEM SAFETY IMPLEMENTATION

Commitment by a company's top management is vital to foster a worthwhile system safety program. In most industrial organizations the basic responsibility for conducting the system safety program is assigned to the project management level. Project management is charged directly with the responsibility for the development of a product or system with the resources available to accomplish this task. Management is then required to plan and implement a proper program to accomplish the goal of a safety designed product. The Department of Defense has been in the forefront of developing and successfully using these system safety concepts. [Ref. 1: p. 31]

E. DEPARTMENT OF DEFENSE SYSTEM SAFETY

Military safety requirements have been set forth in Army Material Command Pamphlet 385-23, U.s. Navy Handbook NVA ORD OD 44942, U. S. Air Force AFCS Design Handbook DH 1-6 as well as U.S. Department of Defense MIL-STD-882A.

The DOD publication MIL-STD-882A, entitled Military Standard System Safety Program Requirements, (SSPR), establishes system safety program objectives and procedures approved for use by all Departments and Agencies of the Department of Defense. The guidelines are not specifically applicable to the non-DOD Coast Guard but are voluntarily followed by Coast Guard program managers involved in major systems acquisitions. The stated principle objective of a system safety program within the Department of Defense is to ensure that safety, consistent with mission requirements, is designed into systems, subsystems, equipment and facilities, collectively referred to as systems. These standards provide uniform requirements for developing and implementing a system safety program of sufficient comprehensiveness to identify the hazards of a system and to ensure that adequate measures are taken to eliminate or control the hazards. All phases of the system life cycle are included, e.g., design, research and development, test and evaluation, production, operation and support, and a modification and disposal. All major as well as non-major yet risk related programs are required to employ system safety program planning. The managing activity[3] or the contractor[4] has the responsibility for developing the plan based on system safety program requirements established by the managing activity. [Ref. 10: p. 1]

Table III-1 [Ref. 10: pp. 2-3], lists many of the terms used in MIL-STD-882A or (SSPR). With minor exceptions, the SSPR is based on the same principles of system safety previously discussed. Stated objectives for system safety programs require the program to define a systematic approach to ensure that:

-- Safety consistent with mission requirements is designed into the system in a timely, cost- effective manner.

-- Hazards associated with each system are identified and evaluated, and eliminated or controlled to an acceptable level throughout the entire lifecycle of a system.

----

[3]Managing Activity, the DOD organizational element of DOD that will plan, organize, direct, contract, and control tasks and associated functions appropriate to the life cycle phase of the system. [Ref. 10: p. 2]

[4]Contractor, a private sector enterprise or the organizational element of DOD engaged to provide services or products within agreed limits specified by the managing activity. [Ref. 10: p. 2]

Table III-1. System Safety Definitions

Mishap. An unplanned event or series of events that result in death, injury, occupational illness, or damage to or loss of equipment or property.

Risk. An expression of possible loss in terms of hazard severity and hazard probability.

Hazard. An existing or potential condition that can result in a mishap (e.g., the presence of fuel in an undesired location is a hazard whereas the fuel itself in not).

Hazard probability. The likelihood, expressed in quantitative or qualitative terms, that a hazard will occur.

Hazard severity. A qualitative assessment of the worst potential consequence, defined by the degree of injury, occupational illness, property damage, or equipment damage that could ultimately occur.

Safety. Freedom from those conditions that can cause death, injury, occupational illness, or damage to or loss of equipment or property.

System. A composite, at any level of complexity, of personnel, materials, tools, equipment, facilities, and software. The elements of this composite entity are used together in the intended operational or support environment to perform a given task or achieve a specific production, support, or mission requirement.

Subsystem. An element of a system that, in itself, may constitute a system.

System safety. The optimum degree of safety within the constraints of operational effectiveness, time, and cost attained through specific application of system safety management and engineering principles whereby hazards are identified and risk minimized throughout all phases of the system life cycle.

System safety engineering. An element of system engineering requiring specialized professional knowledge and skills in applying scientific and engineering principles, criteria, and techniques to identify, eliminate, or control system hazards.

Table III-1. Cont'd

System safety group. A formally chartered group of persons organized to assist the program manager in achieving the system safety objectives.

System safety management. An element of management that establishes the system safety program requirements and ensures the planning, implementation and accomplishment of tasks and activities to achieve system safety consistent with the overall program requirements.

System safety program. The combined tasks and activities of system safety management and system safety engineering that enhance operational effectiveness by satisfying the system safety requirements in a timely, cost-effective manner throughout all phases of the system life cycle.

System safety program plan (SSPP). A formal document that fully describes the planned safety tasks required to meet the system safety requirements, including organizational responsibilities, methods of accomplishment, milestones, depth of effort, and integration with other program engineering and management activities and related systems.

-- Historical safety data generated by other systems are considered and used, where appropriate.

-- Minimum risk is involved in accepting and using of new designs, materials, and production and testing techniques.

-- Retrofit actions required to improve safety are minimized through the timely inclusion of safety features during development and acquisition of a system.

-- Modifications do not degrade the inherent safety of the system.

-- Consideration is given to safety and ease of disposal and demilitarization of any hazardous materials associated with the system. [Ref. 10: p. 3]

The SSPR identifies milestones each with specific safety tasks to be performed at associated phases in the system lifecycle. These phase tasks are very similar in content and purpose, though more definitive, to those phase tasks previously covered. For example, during the program initiation phase, the following is a list of the required system safety tasks:

-- Evaluate all material, design features, procedures and operational concepts and environments under consideration which will affect safety throughout the lifecycle.

-- Perform a preliminary hazard analysis (PHA) to identify hazards associated with each alternative concept.

-- Identify possible safety interface problems.

-- Highlight special areas of safety consideration, such as system limitations, risks, and man-rating requirements.

-- Review safe and successful designs of similar systems for consideration in alternative concepts.

-- Define the system safety requirements based on past experience with similar systems.

-- Identify safety requirements that may require waiver during the system lifecycle.

-- Identify any safety design analysis, test, demonstration and validation requirements.

-- Document the system safety analyses, results, and recommendations for each promising alternative system concept.

-- Prepare a summary report of the results of the system safety tasks conducted during the program initiation phase to support the decision-making process.

-- Tailor the system safety program for the subsequent phases of the lifecycle and include detailed requirements in the appropriate demonstration and validation phase contractual documents. [Ref. 10: pp. 4-5]

Similarly detailed tasks descriptions re prescribed for the engineering development phase, the production and deployment phase and the modification and disposal phase.

It is the responsibility of the managing activity to:

-- Establish, plan, organize, and implement an effective system safety program that is integrated into all lifecycle phases.

-- Establish definitive system safety program requirements for the procurement or development of a system. The requirements to be set forth clearly in the appropriate system specifications and contractual documents and define:

  -- In the appropriate system specifications, the system safety performance and design requirements that are available and applicable.

  -- In the statement of work, the system safety requirements that can't be defined in the system specifications. This would include general design guidelines.

  -- In the statement of work and contract or data requirements list as applicable,the specified safety data; e.g., analyses, tests or progress reports that will be required during the scope of the effort.

-- Ensure that an SSPP is prepared that reflects in detail how the total program is to be conducted.

-- Review and approve for implementation the SSPP's prepared by the contractor.

-- Supply historical safety data as available.

-- Monitor contractor's system safety activities and review and approve deliverable data to ensure adequate performance and compliance with system safety requirements.

-- Ensure that the appropriate system specifications are updated to reflect results of analyses, tests, and evaluations.

-- Evaluate new design criteria for inclusion into military specifications and standards and submit recommendations to the respective responsible organization.

The system safety program outlined in the SSPR requires that a safety organization be established for the conduct and management of the system safety program for both the managing activity and contractor. The responsibilities and functions for those directly associated with system safety policies and implementation of the program must be clearly defined. The authority delegated to this organization and the relationship between line, staff, and interdepartmental, project, functional, and general management organization shall be identified. Personnel assigned to the system safety program shall be identified including their qualifications, specific experience, and formal education or training. [Ref. 10: p. 9]

The SSPR Standard details the means by which hazards can be controlled, e.g., safety devices, warning devices, establishment of procedures and training in addition to describing various analytical techniques to be used throughout the various phases; e.g., risk assessment, establishing environmental constraints, etc. Examples of such analytic tools presented include:

-- <u>Fault hazard analysis</u> -- an inductive method of analysis which can be used exclusively as a qualitative analysis, or, if desired, expanded to a quantitative one. The fault hazard analysis requires a detailed investigation of the subsystems to determine component hazard modes, causes of those hazards, and resultant effects to the subsystem and its operation.

-- Fault tree analysis -- a deductive analytical tool used to analyze all events, faults, and occurrences and all their combinations that could cause or contribute to the occurrence of a defined undesired event. A qualitative or quantitative analysis may be conducted.

-- Sneak Circuit Analysis -- conducted on hardware and software to identify latent (sneak) circuits and conditions that inhibit desired functions or cause undesired functions to occur, without a component having failed. The analysis employs recognition of topological patterns which are characteristic of all circuits and electrical/electronic systems. [Ref. 10: pp. 13-14]

The SSPR standard is consistant with current system safety concepts and serves as a comprehensive guide for project managers in assuring that safety is given maximum consideration throughout the life cycle of a product or system and hence that the product or system is as safe as practicable for the users.

IV. LIGHTER THAN AIR SAFETY

One of the functions of a system safety organization is to review histories when available, of hazards, failures and mishaps in existing systems to ensure that design deficiencies are not repeated in new systems, designs or products. Conveniently, for the Coast Guard, such a history of LTA safety records has been compiled and maintained by the U.S. Navy Safety Center covering the Navy's extensive operating experience with LTA's. An examination of this statistical record provides some insight into the general nature of the safety hazards and risks experienced by the Navy and therefore offers some potential benefit for the Coast Guard LTA project managers. This chapter examines the Navy's records.

Another function of a system safety organization is to participate in preparations and reviews to ensure that incompatible or unsafe subsystems are not incorporated into otherwise acceptable systems. In a sense, a Coast Guard LTA system, a fleet of LTA's could be considered a subsystem. Considering all comparable vehicles currently comprising the Coast Guard's inventory--ships, helicopters, and fixed wing aircraft--the LTA project can be viewed as a potential addition to an existing system--a system comprised of 'operational platforms'. Taken as a whole, the inventory of existing operational platforms has associated with it some overall degree of safety. The inclusion of a new platform, such as a fleet of LTA's would potentially lower, raise or result in no change to this overall degree of safety, depending of course on the safety risks associated with LTA's. A comparative analysis of the hazards, failures and mishaps associated with LTA's, from the Navy's records, and recent records for currently operational Coast Guard platforms, may provide some clue as to what impact the acquisition of an LTA fleet may have on the current overall degree of safety experienced by the Coast Guard. Therefore this chapter examines not only the Navy LTA records but also records of aviation platforms operational currently in the Coast Guard.

A. NAVY AIRSHIP ACCIDENT HISTORY

The historical airship data obtained from the Navy Safety Center covers a period from 1946 to 1961. The information includes:

-- Extent of damage
-- Mishap type
-- Mishap cause
-- Mishap date
-- Phase of Operations
-- Accident location
-- Injuries/fatalities

During the 15 year period from 1946 through 1961, the record shows a total of 207 accidents, approximately 14 accidents per year. The leading cause of these accidents was attributed to pilot error. Of the causes listed for these accidents, pilot error accounted for 39 percent. Accidents caused by personnel handling and ground facilities accounted for 23 percent while weather accounted for 21 percent and equipment failure accounted for 17 percent.

The accidents occurred during one of three phases of operations: flight, landing/takeoff, or 'not incidental to flight' (on the ground). By far the most frequent phase accidents occurred during was that of landing/takeoff. 50 percent of the accidents occurred during landing or takeoff, 18 percent during flight and 32 percent were classified as occurring 'not incidental to flight'.

Approximately 46 percent of the 207 accidents reported were categorized, according to degree of damage, as major accidents (destroyed or substantial damage) with the remaining 54 percent categorized as less than major (limited or minor damage). Of the major accidents, 70 percent were flight related (landing/takeoff or inflight) and of the non-major accidents, 80 percent were flight related. Collision with the ground, water, or other unintended obstacle was the major cause of airship damage figuring into 69 percent of all accidents reported. In only 2 percent of all accidents were fatalities recorded. In 6 percent of the accidents survivors sustained major injury while minor injuries resulted from 9 percent of the accidents. [Ref. 11]

Piecing together these statistics, the most common scenario for an airship accident involved a pilot unintentionally causing collision, during landing or takeoff, resulting in minor damage to the airship and its occupants.

B. COAST GUARD AVIATION ACCIDENTS

This section examines the actual experience of the Coast Guard with aviation mishaps in recent years. The data examined covers a two year period: FY 1982 and FY 1983. The aircraft involved in these mishaps are representative of all the types of aircraft in the Coast Guard inventory during the period:

-- C130, four engine, fixed wing
-- HU16, twin engine, fixed wing
-- HU25, twin engine, fixed wing
-- H3, twin engine helicopter
-- H52, single engine helicopter
-- C131, twin engine, fixed wing

The Coast Guard categorizes aviation mishaps by extent of damage and personnel injury. There are four such classifications, defined as follows [Ref. 12]:

-- <u>Mishap Class A</u>: Total cost of property damage, injury, and occupational illness is $500,000.00 or more, or, the aircraft is missing, abandoned, destroyed, or uneconomically repairable, or, a fatality is involved.

-- <u>Mishap Class B</u>: Total cost of property damage, injury, and occupational illness is at least $100,000.00 but less than $500,000.00.

-- <u>Mishap Class C</u>: Total cost of property damage is at least $10,000.00 but less than $100,000.00, or, injury or occupational illness result in a lost workday case involving days away from work.

-- Mishap Class D: Total cost of property damage is greater than $1,000.00, or, an injury or occupational illness results in a lost workday case involving days of restricted work activity or a non-fatal case without lost work days, or, a significant potential for a near-mid-air collision existed.

The mishaps are also categorized as follows:

-- By operational mode, either in flight or on the ground

-- By primary cause factor:

  -- Environment
  -- FOD (foreign object damage)
  -- Mechanical
  -- Near Midair collision
  -- Personnel

-- By type of mission on which mishap occurred

Of the 707 mishaps recorded during the period 1.5 percent were Class A, 1.4 percent Class B, 23 percent Class C, and 74 percent Class D. Almost 92 percent of all mishaps occurred in flight with only 8 percent occurring on the ground. By cause factor, 15 percent were attributed to environment, .4 percent to near-mid-air, 4 percent to FOD, 65 percent to mechanical failure, and only 16 percent were attributed to personnel. Counting Class A and Class B mishaps as 'major' and Class C and Class D as 'minor' mishaps, 2.9 percent of the mishaps were major and the remaining 97.1 percent were minor. Less than one percent of the mishaps resulted in fatality.

Given the data, the most likely scenario for an aviation mishap in the Coast Guard would involve an inflight mechanical failure resulting in minor damage to the aircraft and its occupants.

C. COMPARISONS

Table IV-1 shows the various percentages tabulated from both the Navy's LTA mishap records and the recent Coast Guard aircraft mishap records. Some significant contrasts are apparent from this comparison.

The most striking difference in the 'causes' information is that the predominant cause cited in Navy LTA mishaps was 'Pilot Error', while the predominant cause for Coast Guard aviation mishaps is 'Equipment Malfunction'. Further, 'Equipment Malfunction' was the <u>least</u> cited cause of LTA mishap while it was the <u>most</u> common cause cited for the Coast Guard aircraft. Some caution is prudent in considering the significance of these differences. These cause determinations were made by different people, working for different services, at different times and on different types of aircraft. Discounting these differences, for the moment, some hypotheses seem plausible and supportable by the contrasts in the data. For instance, the percent of mishaps attributed to equipment or mechanical malfunction going from17 percent for the LTA to 65% for the Coast Guard aircraft, may be explained by the relative degree of simplicity associated with the old LTA craft contrasted with the more technologically sophisticated aircraft of today's

Table IV-1. Mishap Characteristics by Percentage
[Refs. 11 and 28]

	LTA	USCG
1. Cause of Mishap		
A. Pilot Error	39%	16%
B. Ground Handling/Facility	23%	4%
C. Weather	21%	15%
D. Equipment Failure	17%	65%
Total	100%	100%
2. Phase of Flight Mishap Occurred During		
A. Landing or Takeoff	50%	92%
B. In Flight	18%	*
C. Not Incident To Flight (on ground)	32%	8%
Total	100%	100%
3. Extent of Damage as a Result of Mishaps		
A. Major Damage	46%	2.9%
B. Minor Damage	54%	97.1%
Total	100%	100%
4. Mishaps Involving Collision		
A. Collision Involved	69%	35%
B. Collision Not Involved	31%	65%
Total	100%	100%
5. Severity of Injury Resulting from Mishap		
A. Resulted in Fatality	2%	1%
B. Resulted in Serious Injury	6%	3%
C. Resulted in Minor Injury	9%	23%
D. Resulted in No Injury	83%	73%
Total	100%	100%

* Distinction between in flight and landing/takeoff phase not recorded in data.

Coast Guard. The difference in percent of mishaps attributable to pilot error, 39 percent for LTA and only 16 percent for modern aircraft is a little less convincingly explainable. One might expect that the faster and more complex modern aircraft might be more demanding on the pilot than the slow and relatively simple LTA's of the Navy, but that is not borne out by this finding. Perhaps the evidence is explained by the difference in degree of controllability. The LTA's, while slower than modern aircraft, were large and less responsive to pilot control input than are modern aircraft. The LTA, with its vastly greater surface area and relatively smaller power plants, were more affected by wind and weather than modern aircraft. The greater difficulty involved in controlling an LTA may well explain the greater incidence of mishaps attributed to LTA pilots. This same control difficulty may explain the significant difference in the percent of mishaps attributable to ground handling, 23 percent for LTA and only 4 percent for Coast Guard aircraft, as well as the smaller difference noted in weather attributed causes.

The breakdown of mishaps by phase of flight also shows some contrast. Where the LTA experienced 38 percent of mishaps during the ground phase--'Not Incidental to Flight', the modern aircraft experienced only 8 percent of mishaps in this phase. The explanation that the LTA's were more difficult to control in wind and weather, even while on the ground, they are difficult to secure against movement by wind, may account for the different statistics.

The difference in category of damage--major vs. minor, is very striking. While 46 percent of reported mishaps for the Navy LTA's were classified as major, less than 3 percent of the Coast Guard aircraft mishaps were so classified. In both the Navy and Coast Guard records most of the mishaps reported were classified as minor. While not denying the strong possibility that the difference in percentage of major mishaps is significant, consideration of the different reporting procedures used should be considered. There is basis for contending that mishaps reporting procedures in recent years are more comprehensive than those of earlier years. As evidence of this, it was not until the mid 1950's that the Navy records tracked mishaps classified as 'Not incident to Flight'.

It may well be that mishaps of a minor nature, such as the Class D mishaps in the Coast Guard data, did not require reports during the earlier years when the Navy records were collected. Class D Coast Guard mishaps did account for 74 percent of all the mishaps recorded and all of the Class D's fall under the category of 'minor', as used here. Recent advances in information processing and in safety program consciousness could explain an increase in recording of mishaps of a minor nature. Discounting of reporting procedures aside, it probably is reasonable to conclude, however, that the percentage of major vs. minor mishaps was somewhat greater for LTA's than for the Coast Guard aircraft.

Another interesting variance noted reveals that, as the direct cause of damage, collision was responsible in 69 percent of the Navy mishaps and only 35 percent of the Coast Guard mishaps. Again, this difference may well be explained by the greater controllability problem of LTA's discussed earlier.

The injury statistics reveal that fatalities and major injuries, as a percentage of total mishaps, were twice as high for the Navy LTA's as for the Coast Guard aircraft, while minor injuries were only half the percentage for LTA's as for modern aircraft. The fact that the percentages of fatality and major injury appear to be double for the LTA, compared to the other aircraft, merits consideration. Much of this difference, however, may be attributable, once again, to reporting requirement differences. This possibility seems supported by the discrepancy between the two aircraft statistics concerning minor injury. While 9 percent of the Navy mishaps resulted in minor injury, 23 percent of the Coast Guard mishaps resulted in minor injury. A more thorough accident reporting system would result in more minor injuries being reported and, with more minor injuries being reported, the relative percentage of major injuries would appear to decrease.

Based on the data in Table IV-1, it appears, compared to modern aircraft, that LTA's experienced more mishaps due to pilot error, that mishaps occurred more often during ground operations 'not incidental to flight', that damage was more severe, that major injury and fatality was more likely to be involved in a typical mishap, and that collision was more likely the cause of damage and injury.

V. CONCLUSIONS

Regrettably, actual statistics on the number of Navy LTA's and number of flight hours was not available and hence possibly significant comparisons between actual accident rates are not possible within the scope of the paper. There are, however some conclusions to be drawn from the data that is available. As observed earlier, the Navy's experience would lead one to expect that operation of similar LTA's would result in mishaps similar in character to those experienced by the Navy. In summary, as opposed to Coast Guard Aircraft, LTA operations appear to result in mishaps characterized more often by: pilot error, collision, ground handling difficulties, major injuries and fatalities--as a proportion of total mishaps. Each of these characteristics suggest significant ramifications of concern to the Coast Guard as consideration of LTA acquisition continues.

An increase in pilot-error related mishaps would be undesireable from everyone's point of view, particularly the pilots involved. In today's competitive Coast Guard, pilot-error mishaps are, more than ever, considered anathema by career minded pilots.

The greater percentage of collision related mishaps also poses some problems. Material and labor are more expensive commodities today than in the past and our airfields and communities around them are more congested and developed than ever before. The possible consequences being more collisions with buildings than, as in the past, with trees, more expensive repairs, more lawsuits--particularly when pilot-error is involved.

The relatively greater percentage of serious injury and fatality associated with an LTA mishap can not be considered an attractive feature by anyone.

Of course the significance of the characteristic mishap profile presented by the LTA data can not be ascertained without data on the frequency of mishaps occurring. Clearly if mishaps occur more frequently in LTA operations than in modern aircraft operations, then a major problem exists. If, however, mishaps can be determined to occur less frequently among LTA's than aircraft currently in use, then favorable consideration may be merited.

What is clear from study of the data available, is that improved maneuverability and controllability should be a priority objective for development of a new LTA vehicle. Solution of this problem would alter favorably the pilot-error, collision, serious injury, ground incident character of the typical LTA mishap. This conclusion is not new however. . The Coast Guard project planners have in fact placed high priority on improving controllability of the LTA design being considered. [Ref. 7: p. 3]

APPENDIX A

MISSIONS AND EQUIPMENT OF THE MPA VEHICLE

Design Missions

Tables I through XXV identify typical MPA missions and equipment and will be the basis for the design and performance of the MPA vehicle system. An examination of airship application to these roles was conducted in Reference 1. Typical mission profiles are provided so that vehicles can be sized and performance analyzed. The design missions shall include the Coast Guard programs of Enforcement of Laws and Treaties (ELT), Marine Environmental Response (MER), Military Operation/Military Preparedness (MO/MP), Marine Science Activities (MSA), Port and Environmental Safety (PES), Search and Rescue (SAR), Short Range Aids to Navigation (NRS) and Ice Operations (IO). The fixed payload for all the above mission profiles is presented in Table I. Note the sensors and avionics shown in these tables are specific items which will be used on the two newest Coast Guard Aircraft, the HU-25 Medium Range Surveillance (MRS) jet and the HH-65A Short Range Recovery (SRR) helicopter. The inclusion of these specific items is intended to illustrate the functional capabilities which are required for the MPA, not to indicate that each of these specific components is required. The contractor shall consider the unique characteristics of the airship and the mission requirements in optimizing sensor and avionic equipment required.

Speeds specified for all profiles (Tables II through XXV) are ground speeds. In addition, a constant headwind penalty of five (5) knots is to be assumed for vehicle sizing against the mission profiles. Note, this five knot headwind is only for the purposes of vehicle and engine sizing; the wind envelope for controllability purposes shall be as defined below.

Enforcement of Laws and Treaties (ELT)

Under this program, the MPA is intended for drug enforcement and fisheries enforcement within the confines of the 200 mile zone surrounding the United States. Note that long endurance operation, a capacity for "hot pursuit" and the ability to hover are required.

ELT Search and Board Profile

This representative mission profile shall be used in sizing the MPA. Specific profile segments are presented in Table II. Necessary payload data are presented in Table III.

Table I. Fixed Equipment and Avionics

Item No.	Description	Performance Equivalent to
1.	Radar, Surface Search	APS-127
2.	Radar, Side Looking	TBD*
3.	IR/UV Line Scanner	AIREYE
4.	Active Gated TV	AIREYE
5.	Aerial Camera	KS-87
6.	Controls/Displays/Recorders	AIREYE
7.	18 Ft Inflatable Boat, Motor and Fuel	TBD
8.	20 Man Life Raft	TBD
9.	Winch/Hoist, Resupply	TBD
10.	Winch, Vessel/Sensor Towing	TBD
11.	50 Cal. Auto Gun, Provision for	TBD
12.	Torpedoes, Provision for	TBD
13.	MAD, Provision for	TBD
14.	Search Light	Nite Sun
15.	Rescue Gear	HH-3
16.	Dewatering Pumps (2)	HH-3
17.	Firefighting Gear	HH-3
18.	Floats, Smoke and Light Types	HH-3
19.	Radio, UHF/AM	AN/ARC-182
20.	Radio, VHF/AM	AN/ARC-182
21.	Radio, VHF/FM	AN/ARC-513
22.	HF	718R-5
23.	LORAN-C	ADL-82

Table I. Fixed Equipment and Avionics (cont'd)

24.	VOR/DME	AN/ARN-123
25.	Glide Slope	AN/ARN-123
26.	Marker Beacon	AN/ARN-123
27.	TACAN	AN/ARN-118(V)
28.	Radio Altimeter	HG-7502AJ
29.	IFF	AN/APX-100
30.	UHF/VHF DF	DF-301E
31.	Remote Magnetic Indicator (RMI)	TBD
32.	Loudhailer	DE-1492A
33.	UALB (Pinger)	Dukane NISF-201B
34.	Crash Position Indicator (CPI) (ELT)	CIR-11
35.	Internal Communication System (ICS)	AUD-22
36.	Flight Control System	TBD
37.	Automatic Flight Control System (AFCS)	TBD
38.	Inertial Navigation System (INS)/Omega	LTN-71
39.	Navcomputer(s)	TBD
40.	Towed Sonar, Provision for	TBD
41.	Cable, for towing vessels/ sensors	TBD
42.	FLIR (Forward Looking Infra-Red)	TBD
43.	Tool and repair kits as required for all above items	TBD
44.	Stokes litter	

Table I. Fixed Equipment and Avionics (cont'd)

45. Appropriate medical kit

*TBD = To be determined.

Table II. ELT Search and Board Profile

Seg Number	Description	Duration (hrs)	Remarks
1	Warm-up, Take off @ Sea Level TOGW, Standard Day ($T=59^{\circ}F$)	0.25	VTO
2	Cruise 250 nm @ 50 kts @ 5000 feet	5.00	
3	Sweep @ 50 kts for 5.0 hrs	5.00	
4	Dash @ 90 kts for 0.5 hrs	0.50	
5	Hover for 0.50 hrs @ 50 feet	0.50	Deploy boarding party and boat
6	Loiter @ 30 kts for 1.0 hr @ 1000 feet	1.00	
7	Hoverfor 0.50 hrs @ 50 feet	0.50	Recover boarding party and boat
8	Sweep @ 50 kts for 4.0 hrs @ 5000 feet	4.00	
9	Repeat Steps #5-8 once	6.00	
10	Cruise 250 nm @ 50 kts	5.00	

Table II. ELT Search and Board Profile (cont'd)

11	Descend and land @ Sea Level	0.25	With 10 percent fuel remaining
	Total Mission Time	28.00	

Note: Add constant 5 kt headwind to compute airspeeds. All speeds required are groundspeeds.

Table III. ELT Search and Board Payload Data

Item Number	Description	Dimensions (LxWxH Ft)	Weight (lbs)	Remarks
1	Crew of 13		2600	200#/man
2	Provisions, General Stores and Potable Water		379	25#/man/day
			2979	

<u>ELT Surveillance Profile</u>

This representative profile shall be used in sizing the MPA. In-flight reprovisioning is assumed. Profile segments are as presented in Table IV and payload data are presented in Table V.

Table IV. ELT Surveillance Profile

Seg Number	Description	Duration (hrs)	Remarks
1	Warm-up, Take off @ Sea Level TOGW, Standard Day ($T=59^{o}F$)	0.25	VTO
2	Cruise to station, 105 nm @ 50 kts @ 5000 feet for 3.00 hrs	3.00	
3	Loiter @ 30 kts for 6.0 hrs @ 5000 feet	6.00	
4	Dash 45 nm @ 90 kts @ 5000 feet	0.50	Contact Invest-igation
5	Loiter @ 25 kts for 0.5 hrs @ 2000 feet	0.50	
6	Cruise back to station 50 nm @ 50 kts	1.00	
7	Repeat 4 thru 6, 4 more times	8.00	
8	Loiter @ 30 kts for for 0.54 hrs @ 5000 feet	0.54	
9	Dash 30 nm @ 90 kts @ 5000 feet	0.34	Contact Invest-igation
10	Loiter @ 25 kts for 0.5 hrs @ 2000 feet	0.50	
11	Return to station, 25 nm @ 50 kts @ 5000 feet	0.50	
12	Repeat 9 thru 11, 4 more times	5.32	
13	Loiter @ 30 kts for 0.54 hrs	0.54	

Table IV. ELT Surveillance Profile (cont'd)

14	Repeat Steps #3-13 9 times	213.66	In-flight re-fuel up to 3 times
15	Return to base, 200 nm @ 50 kts @ 5000 feet	4.00	
16	Descend and land	0.35	With 10 percent fuel remaining
	Total Mission Time	245.00	

Note: Add constant 5 kt headwind to compute airspeed. All speeds required are groundspeeds.

Table V. ELT Surveillance Payload Data

Item Number	Description	Dimensions (LxWxH Ft)	Weight (lbs)	Remarks
1	Crew of 13		2600	@ 200#/man
2	Provisions, General Stores and Potable Water		1625	@ 25#/man/day for 5 days (balance is added during in flight re-provisioning)
			4225	

Marine Environmental Response (MER)

Under this program, the MPA is intended for use in surveillance, supply and/or towing of heavy and/or outsized equipment, and communication, command, and control (including illumination of the surface) at a specific location for long duration. A hover capability is required.

MER Clean-Up Profile

This representative mission profile shall be used in sizing the MPA. specific profile segments are presented in Table VI and payload data are presented in Table VII.

MER Low-Speed Tow Assessment Profile

In addition to the analysis above, a critical assessment shall be made of the MPA's ability to tow operating oil recovery devices at controllable ground speeds of less than or equal to 1.5 knots. Specific profile segments are presented in Table VIII and payload data are presented in Table IX.

MER Cargo Sled Delivery Profile

This representative mission profile is presented in segment fashion in Table X. Payload data are presented in Table XI.

Table VI. MER Clean-Up Profile

Seg Number	Description	Duration (hrs)	Remarks
1	Warm-up, Take-off @ Sea Level TOGW, Standard Day (T=59^{o}F)	0.25	VTO
2	Cruise 50 nm @ 50 kts @ 2000 feet	1.0	
3	Hover for 0.5 hrs @ 100 feet	0.50	Pick-up mission payload

Table VI. MER Clean-Up Profile (cont'd)

4	Cruise 25 nm @ 50 kts @ 1000 feet	0.50	
5	Hover @ 100 foot altitude for 0.5 hrs	0.50	Off-load payload
6	Cruise 25 nm @ 50 kts @ 1000 feet	0.50	
7	Repeat Steps #3-6 two times	4.00	
8	Loiter @ 30 kts for 3.5 hrs @ 2000 feet	3.50	Perform C^3 function
9	Cruise 75 nm @ 50 kts	1.50	
10	Descend and land	0.25	10 percent of fuel must remain
	Total Mission Time	12.50	

Note: Add constant 5 kt headwind to compute airspeed. All speeds required are groundspeeds.

Table VII. MER Clean-Up Payload Data

Item Number	Description	Dimensions (LxWxH Ft)	Weight (lbs)	Remarks
1	Crew of 8		1600	@ 200# per man
2	Provisions, General Stores and Potable Water		104	@ 25#/man/day
3	Chemicals for Spill		500	
4	Harbor Oil Boom		440	1 @ 2#/ft
5	Oil Recovery	28x27.5x11.5	17,900	Surface Skimmer
			20,544	

Table VIII. MER: Oil Recovery Device Towing Profile

Seg Number	Description	Duration (hrs)	Remarks
1	Warm-up, Take-off @ Sea Level TOGW, Standard Day ($T=59^{O}F$)	0.25	VTO
2	Cruise 50 nm @ 50 kts @ 2000 feet	1.00	
3	Hover for 0.5 hrs @ 100 feet	0.50	Pick-up Equipment
4	Cruise 25 nm @ 50 kts at 1000 feet	0.50	
5	Hover for 0.5 hrs @ 100 feet	0.50	Offload Equipment Hook up to tow
6	Tow Oil Recovery Device @ 1.5 kts @ 200 feet for 6 hrs	6.00	Drag=1000 lbs
7	Hover for 0.5 hrs @ 100 feet	0.50	Disconnect (Leave oil device at the scene)
8	Cruise back to base 100 nm @ 50 kts @ 1500 feet	2.00	
9	Descend and Land	0.25	
		11.50	

Note: Add constant 5 kt headwind to compute airspeed.
All speeds required are groundspeeds.

Table IX. MER: Oil Recovery Device Towing Payload Data

Item Number	Description	Dimensions (LxWxH Ft)	Weight (lbs)	Remarks
1	Crew of 8		1600	@ 200#/man
2	Oil Skimmer	28x27.5x11.5	17,900	
3	Provisions, General Stores and Potable Water		96	@ 25#/man/day
			19,596	

Table X. MER: Cargo Delivery Sled Profile

Seg Number	Description	Duration (hrs)	Remarks
1	Warm-up, Take-off @ Sea Level, TOGW Standard Day ($T=59^{o}F$)	0.25	VTO
2	Cruise 50 nm @ 50 kts @ 2500 feet	1.00	
3	Hover @ 200 feet for 0.5 hrs	.50	
4	Tow sled 100 nm @ 40 kts	2.50	D=5500 lbs
5	Hover @ 200 feet for 0.5 hrs	.50	
6	Loiter @ 30 kts for 6.0 hrs @ 5000 feet	6.00	
7	Cruise back 150 nm @ 50 kts @ 2500 feet	3.00	
8	Descend and Land	.25	VTO
		14.00	

Note: Add constant 5 kt headwind to compute airspeed. All speeds required are groundspeeds.

Table XI. MER: Delivery Sled Payload Data

Item Number	Description	Dimensions (LxWxH Ft)	Weight (lbs)	Remarks
1	Crew of 8		1600	@ 200# per man
2	Provisions, General Stores and Potable Water		117	@ 25#/man/day
			1717	

Military Operation/Military Preparedness (MO/MP)

Under this program mission roles will include patrol, Anti-Submarine Warfare (ASW), ocean industry protection, convoy escort, logistics and inshore, undersea warfare. Required abilities include long endurance, hover, "hot pursuit" and attack.

MO/MP ASW (Towed Array and Attack) Profile

This representative mission profile shall be used for MPA sizing purposes. Specific profile segments are presented in Table XII and payload data are presented in Table XIII.

Table XII. MO/MP ASW (Towed Array and Attack) Profile

Seg Number	Description	Duration (hrs)	Remarks
1	Warm-up, Take-off @ Sea Level TOGW, Standard Day ($T=59^{o}F$)	0.25	VTO
2	Cruise 300 nm @ 40 kts @ 5000 feet	7.50	
3	Tow array @ 10 kts for 0.50 hrs @ 500 feet	0.50	Tow drag= 2300#
4	Cruise 15 nm @ 30 kts @ 1000 feet	0.50	
5	Repeat Steps #3-4 fourteen times	14.00	
6	Dash 90 nm @ 40 kts @ 500 feet	1.00	
7	Localize target @ 40 kts @ 500 feet	0.34	
8	Attack @ 40 kts @ 500 feet	0.16	Deploy (2) torpedoes
9	Cruise 100 nm @ 40 kts @ 2500 feet	2.50	
10	Descend and land	0.25	10 percent of fuel must remain
	Total Mission Time	27.00	

Note: Add constant 5 kt headwind to compute airspeed. All speeds required are groundspeeds.

Table XIII. MO/MP ASW (Towed Array and Attack) Payload Data

Item Number	Description	Dimensions (LxWxH Ft)	Weight (lbs)	Remarks
1	Crew of 13		2600	@ 200# per man
2	Provisions, General Stores and Potable Water		366	@ 25#/man/day
3	Towed Array System		1500	includes processor (400)
4	Torpedoes		1524	MK-46 NT (3)
5	VLA/DIFAR Sonobuoys		200	20 Dwarf-type
6	Marker, BT,AN		300	MK58, SSQ-36, SSQ-57A
7	MAD Gear		400	
8	Displays, Controls		600	
9	AN/ALQ-142 ESM		70	extend overt and cover
			7560	

<u>MO/MP ASW (Mine Countermeasures) Profile</u>

This representative profile shall be used for MPA sizing purposes. The ability of MPA to perform this mission shall be discussed. Profile segments are presented in table XIV and payload data are presented in Table XV.

Table XIV. MO/MP ASW (Mine Countermeasures) Profile

Seg Number	Description	Duration (hrs)	Remarks
1	Warm-up, Take-off @ Sea Level TOGW, Standard Day ($T=59^{o}F$)	0.25	VTO
2	Cruise 25 nm @ 50 kt at 2000 feet	0.50	
3	Hover	0.25	Pick up equipment
4	Tow MCM gear @ 30 kt at 200 feet for 3.0 hrs	3.00	Drag of 5778#
5	Hover	0.25	
6	Repeat Steps #2-4 two times	8.00	
7	Cruise back to base, 50 nm @ 50 kt at 2000 feet	1.00	
8	Descend and land	0.25	10 percent of fuel remaining
	Total Mission Time	13.50	

Note: Add constant 5 kt headwind to compute airspeed. All speeds required are groundspeeds.

Table XV. MO/MP ASW (Mine Countermeasures) Payload Data

Item Number	Description	Dimensions (LxWxH Ft)	Weight (lbs)	Remarks
1	Crew of 8		1600	@ 200#/man
2	Provisions, General Stores, Potable Water		104	@ 25#/man/day

Table XV. MO/MP ASW (Mine Countermeasures) cont'd

3	Marker, BT, AN	300	
4	Sweeping Gear	9000	MK-105 type
		11,004	

Marine Science Activities (MSA)

Under this program airships are projected for use in International Ice Patrol (IIP), Airborne Radiation Thermometry (ART), and NOAA data buoy support. Necessary vehicle attributes include long endurance, low visibility operation, low vibration, safe low altitude operation and hover.

MSA Ice Patrol (St. Johns) Profile

This representative mission profile shall be used in sizing the MPA system. Specific mission profile segments are presented in Table XVI and payload data are presented in Table XVII.

Table XVI. MSA Ice Patrol (St. John's) Profile

Seg Number	Description	Duration (hrs)	Remarks
1	Warm-up, Take-off @ Sea Level TOGW, ($t=30^{o}F$)	0.25	VTO
2	Cruise 100 nm @ 40 kts at 1000 feet	2.50	

Table XVI. MSA Ice Patrol (St. John's) Profile cont'd.

3	Cruise at 60 kts for 30 hrs at 1000 feet	30.00	
4	Cruise 100 nm @ 40 kts at 1000 feet	2.50	
5	Descend and Land	0.25	10 percent of fuel remaining
	Total Mission Time	35.50	

Note: Add constant 5 kt headwind to compute airspeed. All speeds required are groundspeeds.

Table XVII. MSA Ice Patrol (St. John's) Payload Data

Item Number	Descriptions	Dimensions (LxWxH Ft)	Weight (lbs)	Remarks
1	Crew of 13		2600	@ 200#/man
2	Provisions, General Stores and Potable Water		481	@ 25#/man/day
3	Buoy Transmitting Terminals (BTT)		600	3 @ 200# each

Port and Environmental Safety (PES)

Under this program the MPA is intended for escort of vessels transporting hazardous cargoes, port traffic control, and delivery of fire fighting equipment.

PES Hazardous Vessel Escort Profile

This representative mission profile shall be used in sizing the MPA system. Specific mission profile segments are presented in Table XVIII and payload data are presented in Table XIV.

Table XVIII. PES Hazardous Vessel Escort Profile

Seg Number	Description	Duration (hrs)	Remarks
1	Warm-up, Take-off @ Sea Level TOGW, Standard Day ($T=59^{o}F$)	0.25	VTO
2	Cruise 50 nm @ 40 kts at 5000 feet	1.25	
3	Loiter at 30 kts for 6.0 hrs	6.00	
4	Cruise 25 nm @ 40 kts	.60	
5	Descend and land	0.25	10 percent of fuel remaining
	Total Mission Time	8.35	

Note: Add constant 5 kt headwind to compute airspeed. All speeds required are groundspeeds.

Table XIX. PES Hazardous Vessel Escort Payload Data

Item Number	Description	Dimensions (LxWxH Ft)	Weight (lbs)	Remarks
1	Crew of 5		1000	@ 200#/man
2	Provisions, General Stores, Potable Water		44	A 25#/man/ day
3*	Dewatering Pumps		110	1 @ 110 # each
4*	Firefighting Equipment Set		90	1 set

5*	Smoke and Light Floats	42	6 of each

*In addition to quantities already in fixed payload (Table I).

Search and Rescue (SAR)

Under this program the MPA will be operated in missions involving long range rescue of personnel and/or disabled vehicles. Required abilities include long endurance, high speed, large payload capacity, hover and vessel tow capacity.

SAR Search, Board and Tow Profile

This representative mission profile shall be used in sizing the MPA system. Specific mission profile segments are presented in Table XX and payload data are presented in Table XXI.

Table XX. SAR Search, Board and Tow Profile

Seg Number	Description	Duration (hrs)	Remarks
1	Warm-up, Take-off @ Sea Level TOGW, Standard Day ($T=59^{o}F$)	0.25	
2	Cruise 25 nm @ 90 kts at 5000 feet	0.38	
3	Search for 1.5 hrs @ 60 kts	1.50	
4	Hover at 100 feet for 0.50 hrs	0.50	Deploy boarding party (4) in inflatable

XX. SAR Search, Board and Tow Profile cont'd.

			able boat
5	Loiter @ 30 kts for 2.0 hrs @ 1000 feet	2.00	
6	Hover at 100 feet for 0.50 hrs	0.50	Recover boarding party (4) and boat and connect tow line
7	Tow 250 ton displacement vessel @ 5 kts for 50 nm @ 200 feet	10.00	Drag = 5000#
8	Descend and Land	0.25	10 percent of fuel remaining
	Total Mission Time	15.38	

Note: Add constant 5 kt headwind to compute airspeed. All speeds required are groundspeeds.

Table XXI. SAR Search, Board and Tow Payload Data

Item Number	Description	Dimensions (LxWxH Ft)	Weight (lbs)	Remarks
1	Crew of 8		1600	@ 200#/man
2	Provisions, General Stores and Potable Water		128	@ 25#/man/day

Short Range Aids to Navigation (NSR)

Under this program the MPA is projected for roles which include buoy discrepancy reporting, buoy placement and logistics. Required abilities of the vehicle include long endurance, precision navigation, and large (bulky) cargo capacity.

Short Range NSR Buoy Maintenance Profile

This representative profile shall be used in sizing the MPA system. Specific mission profile segments are presented in Table XXII and payload data are presented in Table XXIII.

Table XXII. NSR Buoy Maintenance Profile

Seg Number	Description	Duration (hrs)	Remarks
1	Warm-up, Take-off @ Sea Level TOGW, Standard Day ($T=59^{o}F$)	0.25	
2	Cruise 150 nm @ 50 kt at 1000 feet	3.00	
3	Hover @ 100 feet for 0.5 hrs	0.50	
4	Cruise 80 nm @ 50 kt at 500 feet	1.60	
5	Repeat Steps #3-4 four times	8.40	
6	Cruise 150 nm @ 50 kt at 1000 feet	3.00	
7	Descend and land	0.25	10 percent fuel remaining
	Total Mission Time	17.00	

Note: Add constant 5 kt headwind to compute airspeed. All speeds required are groundspeeds.

Table XXIII. NSR Buoy Maintenance Payload Data

Item Number	Description	Dimensions (LxWxH Ft)	Weight (lbs)	Remarks
1	Crew of 8		1600	@ 200#/man
2	Provisions, General Stores and Potable Water		142	@ 25#/man/day
3	Buoy Maintenance Kit		500	
			2242	

Ice Operations (IO)

Under this program the airship is intended for the mission of Aerial Ice Reconnaissance (AIR). The platform will require the ability to perform long range operations, to carry large sensors (such as Side Looking Airborne Radar-SLAR) with associated processing equipment and to operate in poor visibility, low altitude and icing conditions.

IO Ice Mapping Profile

This representative mission profile shall be used in sizing the MPA. The specific mission profile segments are presented in Table XXIV and the payload data are presented in Table XXV.

Table XXIV. IO Ice Mapping Profile

Seg Number	Description	Duration (hrs)	Remarks
1	Warm-up, Take-off @ Sea Level TOGW, ($T=30^{o}F$)	0.25	VTO
2	Cruise @ 60 kts for 13 hrs @ 5000 feet	13.00	
3	Map @ 60 kts for 13 hrs @ 5000 feet	13.00	
4	Hover @ Sea Level 1 hour to refuel @ 100 feet	1.00	Refuel
5	Same as segment 3	13.00	
6	Same as segment 2	13.00	
7	Descend and Land	0.25	10 percent fuel remaining
	Total Mission Time	53.50	

Note: Add constant 5 kt headwind to compute airspeed. All speeds required are groundspeeds.

Table XXV. IO Ice Mapping Payload Data

Item Number	Description	Dimensions (LxWxH Ft)	Weight (lbs)	Remarks
1	Crew of 13		2600	@ 200#/man
2	Provisions, General Stores and Potable Water		650	@ 25#/man/day
3	Scientific Instruments		1000	
			4250	

LIST OF REFERENCES

1. Roland, H.E., and Moriarty, B., System Safety Engineering and Management, Wiley-Interscience Publication, 1983.

2. Airship Industries, Skyship 500/600: The Off-Shore Tapestry Role, Data Sheet 12 Issue 2.

3. Garrett, J.M., Artic Alaska and Icebreaking: an Assessment of Future Requirements for the United States Coast Guard, Master's Thesis, Naval Postgraduate School, Monterey, California, 1981.

4. Commandant, United States Coast Guard (G-BPA-2), Public Affairs Information Release, Subject: Budget and Resources Data, 1983.

5. Center for Naval Analyses Report CNS 1078 - Vol. I, Coast Guard Lighter-Than-Air Study Main Text,1 by R.E. Beatty and R.D. Linnell, October 1976.

6. United States Coast Guard, LTA Point Paper, paper prepared for Senate Budget Hearings FY 82 Budget, 1981.

7. United States Coast Guard Project: Lighter-Than-Air System Concept Definition Report G-D 2000A Revision 3, Project Master Plan Narrative, December 1982.

8. United States Coast Guard Project: Lighter-Than-Air System Concept Definition Report G-D 2000A Revision 1, Project Master Plan Narrative, January 1981.

9. Naval Air Development Center Solicitation N62269-81-R-0715, Maritime Patrol Airship System Demonstrator, F. Akinfosile, 17 November 1981.

10. Department of Defense Military Standard MIL-STD-882A, system Safety Program Requirements, 28 June 1977.

11. Naval Safety Center Report 01652FA, Special Study, computer printout presented to United States Coast Guard Project Manager, 22 October 1980.

12. United States Coast Guard, Commandant Instruction M5100.29, Subject: Occupational Health and Safety, March 1978.

13. Defense Documentation Center SC-070517, Airships (u) a Report Bibliography, 8 October 1971.

14. Cranfield Institute of Technology, Great Britain CTS Report 3, An Appraisal of the Rigid Airship in the UK Flight Market, by S. Coughlin, March 1973.

15. National Aeronautics and Space Administration CR-2636, Cargo Transportation by Airships: A Systems Study, by C.J. Huang and C. Dalton, May 1976.

16. National Aeronautics and Space Administration CR-137692, Vol. 1, Feasibility Study of Modern Airships, August 1975.

17. Goodyear Aerospace Corporation, Feasibility Study of Modern Airships, Phase II, Vol. III, July 1977.

18. Malasky, S.W., System Safety, Planning/Engineering/Management, Hayden Book Company, Inc., 1980.

19. Department of the Navy NAVORD OD 44942 (Navy), Weapon System Safety Guidelines Handbook, System Manager's Guide to System Safety, Part I, 23 April 1973.

20. Toland, J., Ships in the Sky, Henry Holt and Company, 1957.

21. Center for Naval Analyses Report CNS 1078-Vol II, Coast Guard Lighter-Than-Air Study Appendices, by R.E. Beatty and R.D. Linnell, November 1976.

22. Department of the Navy OPNAV Instruction 3750.6N (Navy), The Naval Aviation Safety Program, 30 November 1982.

23. Department of the Navy NAVSAFECEN 3750 P1 (Navy), Naval Safety Center Aviation Safety Review Checklist, October 1981.

24. Department of the Navy, Aviation Safety Officers Course, course presented at Naval Postgraduate School, Monterey, California, October 1983

25. Naval Air Development Center, Patrol Airship Concept Evaluation (PACE), 1982.

26. Mcginlay, T.C., Personnel and Equipment Design Concept for a Maritime Patrol Airship (Non-Rigid) to Conduct Search, Antisubmarine Warfare, and Airborne Mine

Countermeasures Missions, Master's Thesis, Naval Postgraduate School, Monterey, California, December 1979.

27. United States Coast Guard Safety Office Report, Computer Generated Mishap Summary, Reports Received During FY 82 and FY 83, computer printout presented to author, 19 September 1983.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22314	2
2.	Library, Code 0142 Naval Postgraduate School Monterey, California 93943	2
3.	Commandant (G-PTE) U.S. Coast Guard Washington, D.C. 20593	1
4.	Professor Roger D. Evered Code 54Ev Department of Administrative Sciences Naval Postgraduate School Monterey, California 93943	2
5.	Professor Donald M. Layton, Code 67 Department of Administrative Sciences Naval Postgraduate School Monterey, California 93943	2
6.	Chairman, Department of Administrative Sciences, Code 54 Naval Postgraduate School Monterey, California 93943	1
7.	Lieutenant Patrick J. Danaher 2916 Titanic El Paso, Texas 79904	2

END

FILMED

5-84

DTIC